03M05B42

INSTRUCTIONS

FOR THE USE OF

ESTERLINE-ANGUS MODEL A. W.

GRAPHIC INSTRUMENTS

INCLUDING CONNECTION DIAGRAMS
AND INSTRUMENT DATA SHEET

THE ESTERLINE-ANGUS COMPANY, INC.
INDIANAPOLIS, INDIANA, U. S. A.

SERIAL NUMBER

THE ESTERLINE-ANGUS COMPANY, INC.

Manufacturers of Electrical Instruments

INSTRUMENT DATA SHEET
ENGINEERING DEPARTMENT

P. O. Box 596
INDIANAPOLIS, U. S. A.

Sold to THE MAGNAVOX COMPANY Order No. V-12081
Address Fort Wayne, Indiana
Sold by Fay Order No.
Mfg. Order No. Sales Order No. ND 41495 Date 8-18-43

Model AW Kind Voltmeter Case Port.
AC-DC AC Wire 2 Phase Single Cycles 60 Movement No. 340
Feeds, Hourly 3/4-1½-3-6-12" Minute 3/4-1½-3-6" Second Clock No. 79-R
Scale Range 0-150 Volts Scale No. V-15-150 Chart No. 1316-C
Full Scale Volts 150-300-600 Amps. Millivolts
Watts R.P.M. Damping No. 3.0 A
Attached Multiplier No. 8850 Ranges 150-300-600 Volts
Separate Multiplier No. Ranges
Insulation Test 5000 Volts for one minute. Inst. Name Plate No. 8912 Mult. Name Plate No.
Current Leads, Quantity Length Size No.
Potential Leads, Quantity 2 Length 5 Ft. Size #14 No. 8935
Internal Diagram No. D-803 Connection Diagram No. D-940
Special

Entered by IRL

BY THE LABORATORY

Range 150 V. Total Ohms, A. 1172 B. Mult. A. 759 B. R. H. Pen Coil Ohms
Range 300 V. Total Ohms, A. 2383 B. Mult. A. 2170 B. Series Resis. Ohms
Range 600 V. Total Ohms, A. 4803 B. Mult. A. 4590 B. L. H. Pen Coil Ohms
Range Total Ohms, A. B. Mult. A. B. Series Resis. Ohms
Armature 213 Ohms. M. V. at Meter A. Comp. A. Trip Coil Ohms
Parallel Cir. Ohms. at rated load B. Comp. B. Generator Resist. Ohms
Total Meter Ohms. Temp., 30 Degs. Cent. Cap. Grams Torque Full Scale 84
Notes

Calibrated by [signature] Inspected by [signature] Date 10/18/43 O. K. by [signature] Supt.

ACCESSORIES

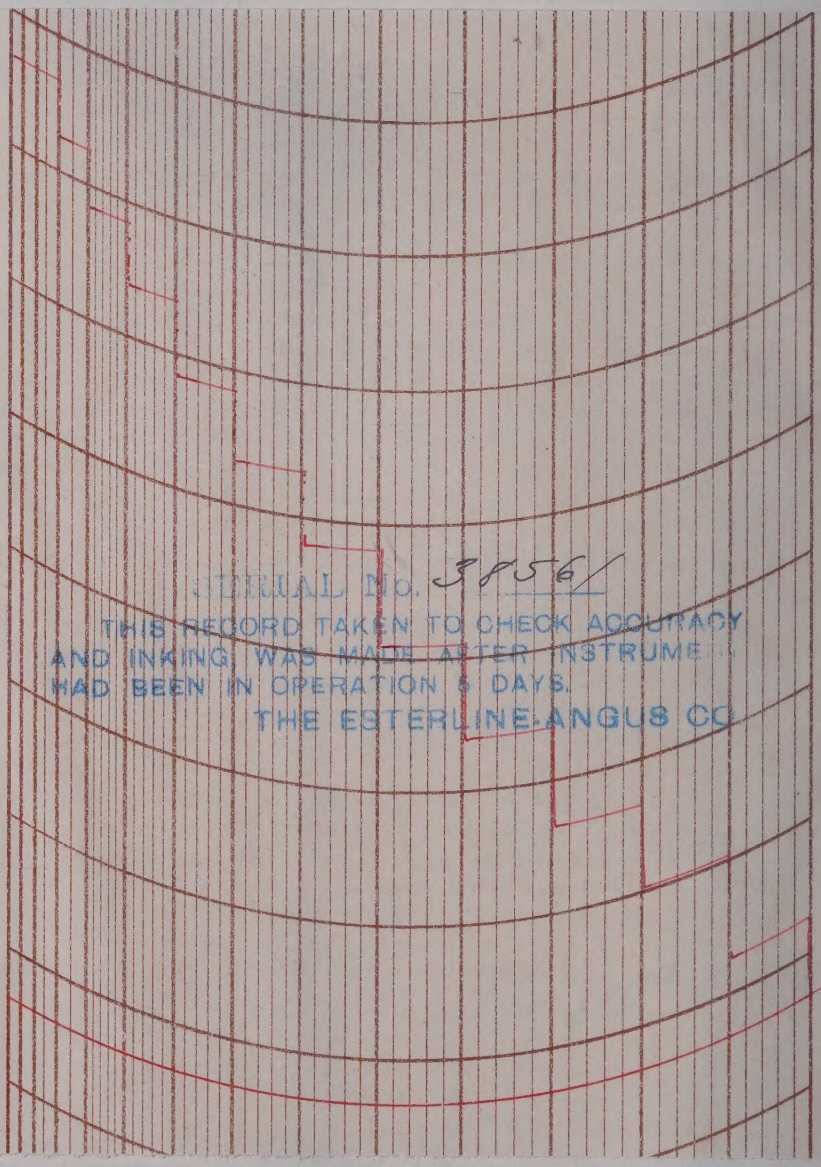
Shunts and Current Transformers

Quantity	Type	Rated Amp.	Millivolts	Amp. at Rated M. V.	Make

Potential Transformers

Quantity	Type	Prim. Volts	Sec. Volts	Cyles	Make

Form 364 SERIAL No. 38561


7
6
5
DIAL No. 39516
THIS RECORD TAKEN TO CHECK ACCURACY
AND INKING, WAS MADE AFTER INSTRUME
HAD BEEN IN OPERATION 6 DAYS.
THE ESTERLINE-ANGUS CO

GENERAL INSTRUCTIONS

FOR

ESTERLINE-ANGUS MODEL AW GRAPHIC INSTRUMENTS

These instructions are a guide to the correct operation of Esterline-Angus graphic instruments. These instructions should be read by the person who uses or services the instruments, and should be kept in a convenient place for reference. Additional copies of this instruction book will be furnished on request.

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UNPACKING

Esterline-Angus instruments are carefully packed; carriers are responsible for damage in transit. If the packing case shows damage, make a notation to that effect on your express receipt or freight bill. If it is found that the shipment has been damaged, notify the carrier at once.

Included with each shipment will be found a packing list, showing every item in the shipment. Check off each item as the goods are unpacked, and if any item appears to be missing, go through the packing material carefully before it is thrown away. The missing articles may have been overlooked when the packing material was removed.

Each instrument is carefully inspected at the Esterline-Angus factory and then sealed before shipment. New instruments are shipped complete with necessary multiplier boxes and leads, one record chart, and a box of accessories containing one two-ounce bottle of red ink, one inkwell filler, one pen filler, and one spare glass pen. Two charts and two accessory boxes are furnished with twin instruments.

On an instrument which is to be permanently installed, it is advisable to leave the seal intact until the instrument is required for use.

INSTALLING

Front switchboard, wall, and flush instruments should be mounted LEVEL in a clean, light place, with the bottom of the instrument about four feet from the floor. The instrument should be mounted where it will not be subjected to vibration or extremes of temperature. If unusual steam, smoke, moisture, dust, or corrosive fumes are present, a protective cabinet should be built around the instrument. Drilling dimensions furnished by the factory should be followed when mounting instruments on panels. Front or flush switchboard instruments can be mounted either on slate or steel panels, the drilling dimensions being furnished for the kind of panel specified when the instrument was ordered. Front switchboard DC instruments are specially calibrated if they are to be mounted on a steel panel. A switchboard DC instrument, if calibrated for the customary insulating panel, will read low if

mounted on a steel panel.

Multipliers for front switchboard and wall type instruments are housed in separate boxes and marked with the instrument serial number. Multipliers for portable and flush instruments are attached directly to the instrument case. All separate multipliers must be mounted vertically. Never put a multiplier in a closed compartment or obstruct the flow of air through it.

Do not locate instruments close to bus bars or cables carrying large currents. This is especially important for DC wattmeters. Bus bars should be kept at least three feet from the meter case.

Switchboard type shunts must be mounted with the blades vertical to permit free circulation of air. Shunts should be mounted with at least three feet of unbroken bus bar extending from both ends. Never crowd a shunt into the bus structure between other shunts, or install it above another shunt.

The cases of portable, front switchboard, and wall type instruments have latches that can be sealed with standard meter seals or locked with a small padlock. Padlocks can be supplied by THE ESTERLINE-ANGUS COMPANY. All flush instruments have a lock built in the case door. Two keys are furnished with each instrument and these keys fit any flush case lock.

SETTING UP FOR USE

To place an instrument in service, break the seal and take off the front cover as follows: Open the latch on top of the case, swing the top of the cover open about six inches and slide the lower end toward the instrument case to disengage the hinges. Lay the cover aside until the instrument is charted and inked. Always keep the cover closed when the instrument is in use. Flush instruments have a door which should be unlocked and swung open for access to the mechanism.

To protect the instrument mechanism during shipment, a cardboard retainer is fitted over the drive roll and pen table and extends into the movement compartment where it engages the pen fork to prevent unnecessary swinging of the moving element. The pen element is carried by two ears on this cardboard cover. Remove the pen element and lay it aside. Pull out the cardboard according to the directions printed on it. The instrument is then ready for filling with ink and inserting the chart, as described later.

CONNECTING

Do not connect the instrument without first referring to the wiring diagrams in this book. A wrong hook-up may cause the instrument to read incorrectly or may cause permanent damage. All terminals are marked with an identifying letter or voltage. Positive instantaneous polarity is indicated by a prime mark (′). This mark appears both on the instrument terminals and on the connection diagrams.

Current leads are furnished with meters used with external shunts, and

are marked with the meter serial number. These meters are calibrated for the correct voltage drop AT THE SHUNT END OF THE LEADS furnished with them, and only these leads can be used. Other connections should be made with #14 wire or larger.

A set of leads is furnished with portable instruments. These leads have taper plugs on the instrument end and open spade terminals on the other end. Keep the plugs and terminals clean to insure good contact. All meter terminals for plug connections are threaded inside so the instrument can also be used with binding post connections. Binding posts can be obtained from THE ESTERLINE-ANGUS COMPANY by giving the serial number of the instrument. Do not use binding posts on any meter operated from shunts. For connections between meter and shunts, only the calibrated leads furnished with the meter may be used.

INSERTING THE CHART. See Illustration Sheets Nos. 539A-1&2.

Take out the reroll stick. Place the hole in the chart core over the buttons on the clock plate and supply roll bracket so that the chart roll is securely held yet free to revolve. The time figures on the chart must be at the left.

Unwind the end of the chart, cut or tear to a "V" shape and insert the end in the slot marked "Insert end of chart here". Push the chart until the end appears over the pen table. Pull the chart over the drive roll, engaging the chart perforations with the drive roll pins. Turn the knurled set wheel on the right hand end of the drive roll until sufficient chart is unwound to reach the reroll stick.

Before attaching the end of the chart to the reroll stick, see that the clip on the reroll disk is at the front. If it is not in this position, turn the disk forward until the clip stops at the front. (This is possible by virtue of a friction clutch in the reroll gear train.) Wrap two or three turns of chart around the reroll stick and replace the stick so that the chart paper is under the clip and the clip is over the flat place on the stick. Release the automatic reroll catch by turning the stick backwards slightly and then letting it turn slowly forward until the slack in the chart is taken up.

The reroll stick should turn freely and have a slight end play. If there are too many layers of chart under the clip, the reroll mechanism will bind. Set the chart to time by turning the set wheel until the writing pen indicates the correct time of day on the chart with reference to the time numbers printed along the left hand edge of the chart.

STARTING THE CLOCK

BE SURE THE CLOCK IS WOUND. Since various types of chart drives are supplied with Esterline-Angus instruments, a special instruction section concerning the chart drive will be found in this book. Read this section carefully before starting the clock.

INSPECTING THE RECORD

The chart can be pulled from the reroll to examine the record. The reroll operates like a window-shade. A sharp jerk on the unrolled chart will lock the reroll, removing tension from the chart and allowing it to be examined at leisure. To rewind the chart, first pull it forward slightly, then let it wind slowly on the reroll stick. Any amount of chart can be pulled from the reroll without damaging the mechanism.

FEEDING CHART THROUGH BOTTOM OF CASE

On all instrument cases except the flush, provision is made for feeding the chart through a slot in the bottom of the case. To feed through instead of rerolling, remove the metal or rubber strip at the lower edge of the case cover. The end of the chart which hangs out of the case should be weighted with a paper clamp. Do not pull or jerk on the end of the chart or it may be thrown out of time.

REMOVING THE CHART

To remove a used chart from the meter, take out the rerolled chart with the reroll stick, and pull the stick out of the chart, using a twisting motion. The chart is then ready for inspection or filing. An Esterline-Angus Chart Inspector is a useful device for routine examination of record charts, and we suggest that it be purchased if a number of charts are to be studied.

CHART FEEDS

Unless otherwise specified, the standard chart feed is three inches per hour. Change gears to provide other chart feeds can be furnished, and will be found on studs at the bottom of the clock mounting plate. The following table shows the combinations of gears to obtain different chart feeds.

DRIVING GEAR No. of Teeth	DRIVEN GEAR No. of Teeth	CHART FEED, Inches Per Hour or Per Minute
18	72	3/4
30	60	1-1/2
45	45	3
60	30	6
72	18	12*

*The 12-inch per minute speed is available but not guaranteed.

To change the rate of chart feed, unscrew the change gear nuts, pull off the existing gears, slide on the desired gears and replace the nuts, being careful to engage the slots in the gear hubs with the keys on the gear shafts. Be sure that the change gear nuts are screwed up tight.

All record charts are six inches wide and are 103 feet long. Time figures are printed along the margin as follows: Charts for 3/4, 1½ and 3 inches per hour have time figures every three inches and are marked A.M. and P.M., using light faced type for A.M. and bold faced type for P.M. Charts for 6 inches per hour have time figures every six inches and also have the A.M. and P.M. designations. Charts for 12 inches per hour have time figures every six inches but do not have the A.M. and P.M. designations. This reduces the amount of chart paper lost when an E-feed chart is set to time.

A letter after the chart number indicates the feed. When ordering charts, be sure to specify the feed by adding the proper letter as follows: "A" for 3/4, "B" for 1½, "C" for 3, "D" for 6, "E" for 12 inches per hour, and "X" for no time markings. The "X" chart without time markings is useful on instruments operated only at minute speeds, or instruments where the chart is operated intermittently.

The minimum running time of charts on various feeds is as follows:

SPEED Inches Per Hour	Feet Used Per Day	Feet Used Per Week	*Minimum Running Time in Days
3/4	1½	10½	65-2/3
1½	3	21	32-1/3
3	6	42	15-2/3
6	12	84	7-1/3
12	24	168	3-2/3

SPEED Inches Per Minute	Feet Used Per Hour	Feet Used Per Day	Minimum Running Time in Hours
3/4	3-3/4	90	26-2/3
1½	7-1/2	180	13-1/3
3	15	360	6-2/3
6	30	720	3-1/3

*Actual running time may exceed the above minimum, depending upon starting time.

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FILLING WITH INK - See Illustration Sheet No. 539A-2.

First raise the scale plate and remove the pen element. Take out the inkwell by lifting the two handles and pulling it forward. Fill the inkwell through the pen opening, about three quarters full, using the ink and the inkwell filler furnished with the instrument. Replace the inkwell, being careful that it is under the spring clips which hold it in place.

Set the pen element in the pen fork properly, with the knife edges of

the element seated in the slots in the fork. The pen element is correctly balanced at the factory WHEN FULL OF INK, and will stay off the chart until the pen is filled. Fill the pen by means of the pen filler furnished with the meter, proceeding as follows: Compress bulb of the pen filler, lay flat side of soft rubber tip on the chart, insert glass pen into hole in rubber tip, and let filler suck ink through the pen until no bubbles are visible in the glass pen. Then remove pen element from filler and the pen should rest lightly on the chart.

Swing the pen across the chart several times. If it does not write properly, the pen probably has an air bubble in it, in which case the pen filling operation must be repeated. Lower the scale plate and make certain that the pen is properly seated in the pen fork and does not rub on the inkwell or scale plate. The indicating target above the glass pen must not touch the scale plate. If the pen is clean and properly primed with all bubbles removed, it will write for long periods without further attention.

CARE OF THE INKING SYSTEM

ESTERLINE-ANGUS graphic meter ink is made especially for use with recording instruments and is the result of long experience and careful research. Other inks should not be used. This ink begins to freeze at about 20 degrees Fahrenheit and if the instrument is subjected to lower temperatures, we recommend mixing the ink with an equal part of pure alcohol.

The inking system should be inspected once a week. Fresh ink should be added to the inkwell; any dirt, lint or dried ink should be removed from the glass pen point, and some ink should be drawn through the pen element by means of the pen filler. Once a month, or oftener on "QUICK TRIP" meters or meters located in hot or dusty places, the inkwell and pen element should be emptied, washed and refilled.

To clean the inkwell, pry off the cover and wash the parts in water. See that the vent holes in the cover are open and that the cover is not bent when removing it. The pen element is best cleaned by blowing water through it with a pen filler. Intermittent writing, failure of the pen to write on sudden swings, a dark purplish color of the record line instead of the normal bright red, or a tendency of the ink to spread in the paper and produce a broad, fuzzy line, are all indications that the ink in the inkwell has thickened and oxidized and that the inking system should be serviced more often. Instruments that operate at high temperatures and instruments involving high chart speeds require special attention to the inking system.

Instruments are shipped with the pen elements properly balanced WHEN FULL OF INK and the balance adjustment should not be changed unless necessary. The pen balance should be such that when the chart is tapped lightly with one finger, the pen will bounce up and down on the chart. Too heavy a pen pressure on the chart will cause the pen to drag toward the center of the chart and thus give a false reading. Handle the pen element carefully; a bent element will cause incorrect readings. The writing tip of the glass pen must be

exactly 4-3/8 inches from the knife edge. An arc line is marked on the pen table, making it easy to check this length without removing the pen element from the instrument.

The glass writing pen is a taper fit in the metal pen tube and is easily removed by twisting it out. The pen is ground at the factory to give a suitable line for most requirements, but extra-fine points can be furnished. If a wider line is desired, grind the point with a fine white Arkansas stone wet with water, being sure to grind the face of the point square. If a glass pen is broken off in the pen tube, it can be removed by running a fine wire clear through the broken pen and tube, tying a small knot in the wire, and then pulling the broken pen out with the wire. In replacing a glass pen, be sure it rests perpendicular to the chart, otherwise it will not write properly. It is convenient to have one or more extra pen elements on hand. These can be cleaned in the shop and changed in the field, without taking the meter out of service.

TECHNICAL INFORMATION

Esterline-Angus graphic instruments are accompanied by a technical data sheet, giving information pertaining to the instrument. This data sheet is a part of the instruction book and should be kept for reference. Part of this information will also be found on the nameplate inside of the case at the bottom. On the back of the data sheet will be found an original record made by the instrument as it was checked at the factory.

SUPPLIES AND PARTS

To obtain the most benefit from the investment which instruments represent, they should be kept in continuous service. Portable instruments should be moved to another job as soon as one job is finished. If the purpose for which the instrument was originally purchased has been fulfilled, the instrument should be used elsewhere to keep it active and thus to distribute its cost over a greater number of jobs.

Although the ESTERLINE-ANGUS factory is prepared to ship charts and ink the same day the order is received, the user should forecast his need for these essential items so that his instrument need never be idle for want of supplies. Keep on hand at all times enough charts and ink to operate each meter for at least one month. By purchasing in larger quantities, worthwhile savings can be made on these items.

Record charts should be ordered by number. This number will be found on the right hand edge of the used chart. When charts of various ranges are available for use on the same meter, a list of such charts is included in this instruction book.

Esterline-Angus ink is supplied in two colors: Red and Green, and is put up in two-ounce and one-pint bottles. Red ink is standard and will be furnished unless otherwise specified.

When ordering parts for this recorder, always give the serial number. This number is stamped on the nameplate inside the meter case, also on the scale plate and on the chart drive name plate.

GUARANTEE

Esterline-Angus instruments are guaranteed to be free from defects due to faulty materials or workmanship. Any instrument proving defective within one year from date of shipment will be repaired or replaced free of charge when returned to our works prepaid, provided the instrument has not been tampered with or misused. We do not assume responsibility for repairs made outside our plant.

PACKING FOR SHIPMENT

If the instrument is to be returned to the factory for repairs, send for shipping instructions and at the same time state clearly the reason for return. If time does not permit this normal handling, the following procedure should be observed: Wash out inkwell and pen element, remove pen element from pen fork and tie it across top of scale plate. Remove studs from switchboard instruments. Protect glass front with a small board and wrap instrument in heavy paper to prevent excelsior from sifting into the mechanism.

BE SURE TO RETURN ANY SEPARATE MULTIPLIERS, AND BE SURE TO RETURN THE LEADS FOR DC WATTMETERS OR AMMETERS. We MUST have these items at the factory when the meter is to be repaired or recalibrated. Return the entire set of leads furnished with portable meters. If the meter being returned is a speed recorder, return the tachometer generator and any indicators used with it. If only the clock is in need of repair, it should be removed from the meter, eliminating the necessity of shipping the entire instrument.

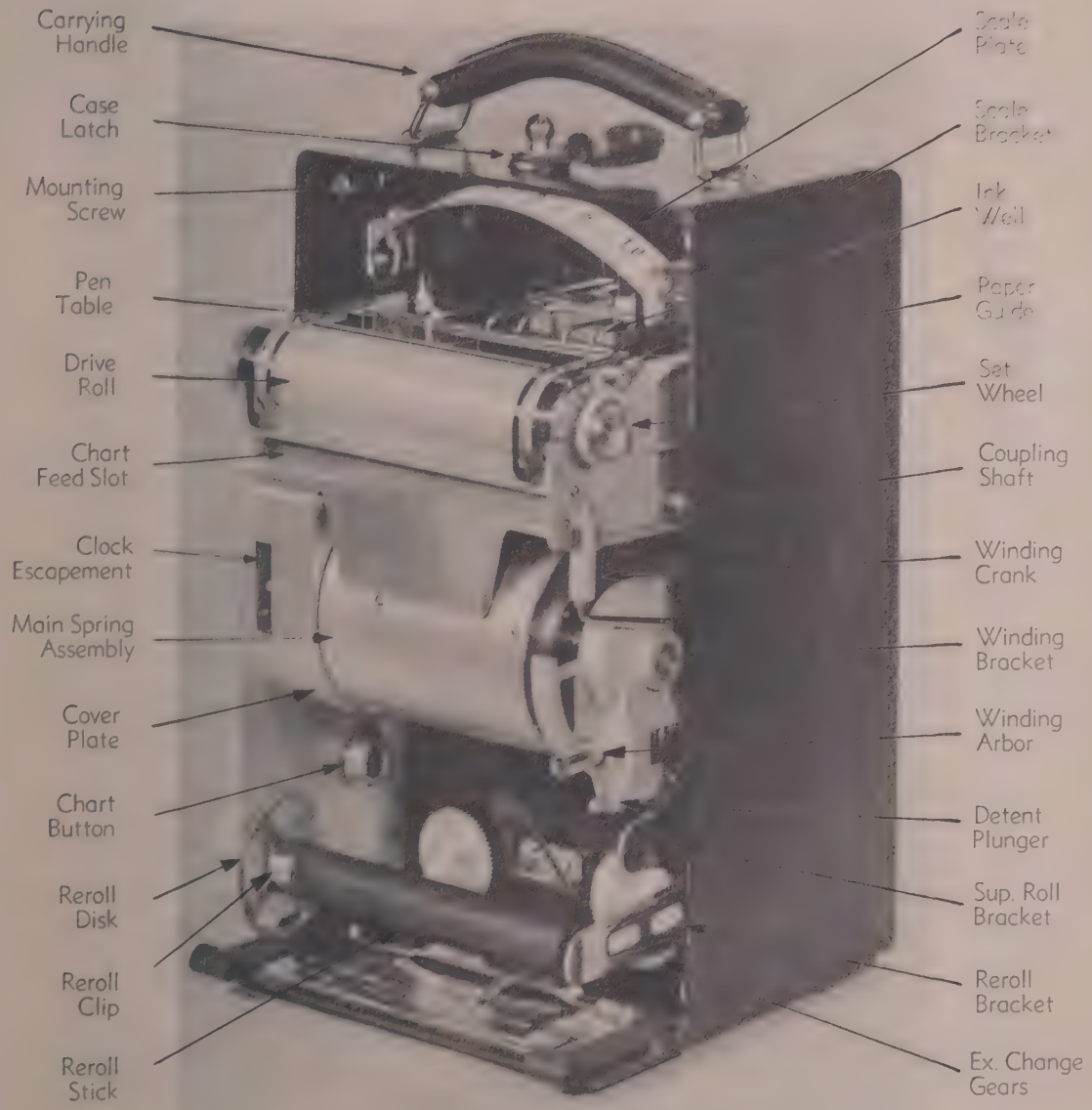
Use a strong, substantial packing box, large enough to permit at least eight inches of dry excelsior on all sides of the instrument. Ship by prepaid express and mark: "Electrical Instrument, Handle Carefully."

THE ESTERLINE-ANGUS COMPANY, INC.,
Indianapolis, Indiana.
U.S.A.

ESTERLINE-ANGUS GRAPHIC RECORDER

ILLUSTRATING

PORTABLE CASE AND SPRING CLOCK



THE ESTERLINE-ANGUS COMPANY, Inc.

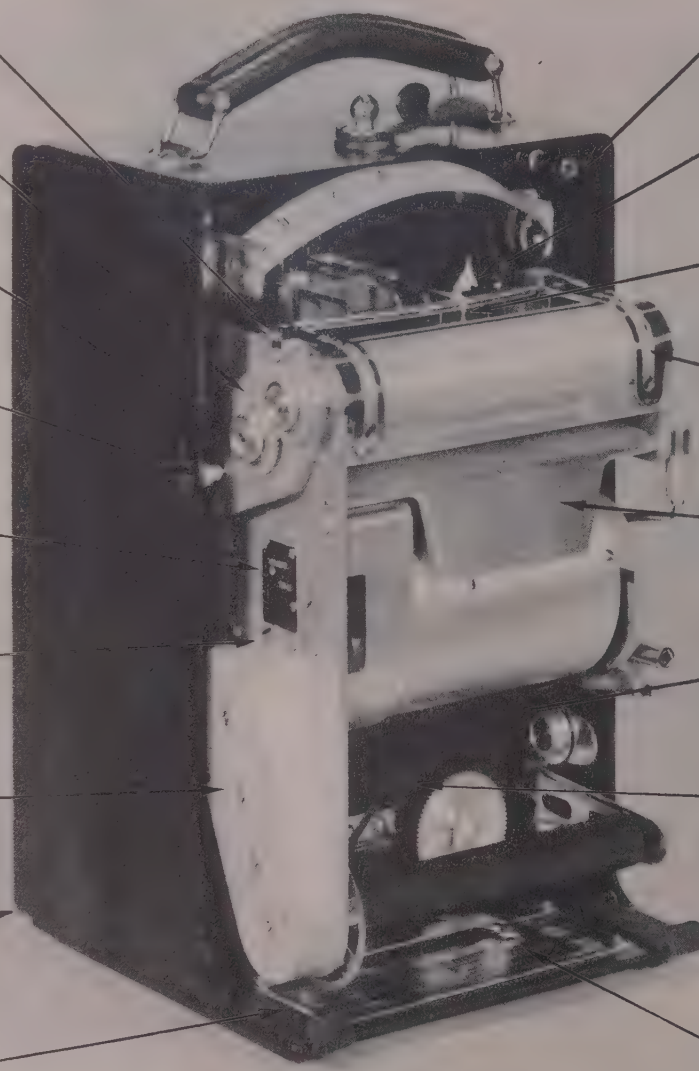
Indianapolis, Ind., U.S.A.

ESTERLINE-ANGUS GRAPHIC RECORDER

ILLUSTRATING

PORTABLE CASE AND SPRING CLOCK

Continued



THE ESTERLINE-ANGUS COMPANY, Inc.
Indianapolis, Ind., U.S.A.

THE ESTERLINE-ANGUS MODEL AW GRAPHIC METER

INSTRUCTIONS FOR PLACING IN SERVICE

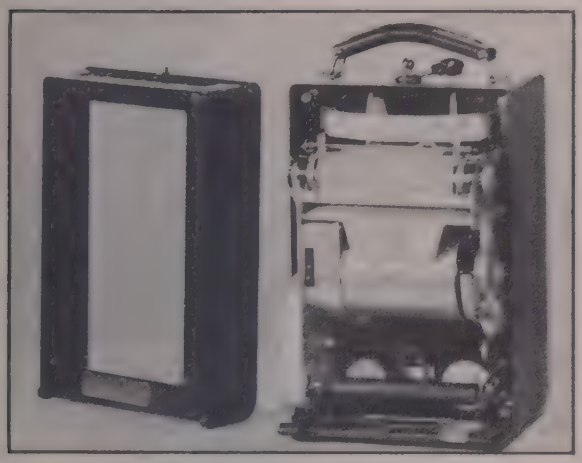


Fig. 1. OPENING METER. Break seal, open latch and remove cover. Take out "tie-up" card.

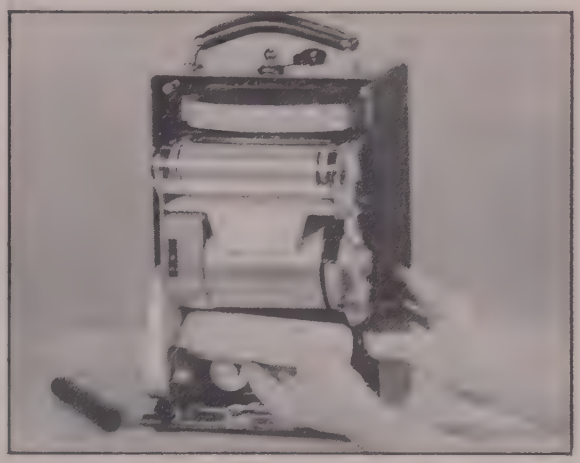


Fig. 2. INSERTING NEW CHART. Remove reroll stick. Insert chart in meter with time [illegible]

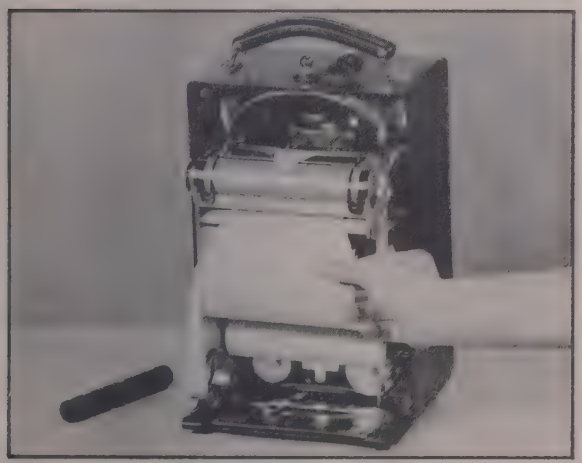


Fig. 3. THREADING CHART. Tear or cut end of chart "V" shaped and insert in feed slot. Push chart until end comes out over pen table.

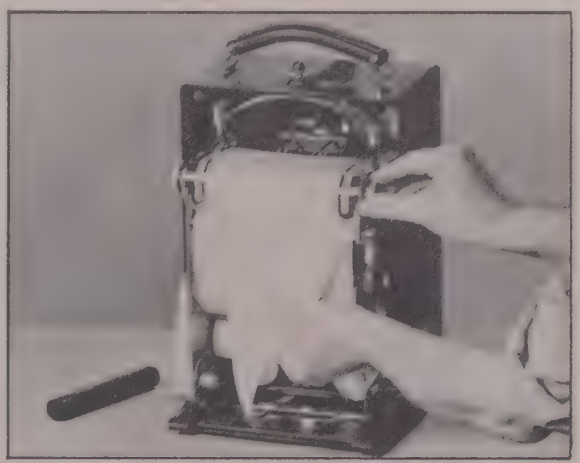


Fig. 4. THREADING CHART CONTINUED. Pull on end of chart and turn set wheel, engaging pins in perforations at edges of chart

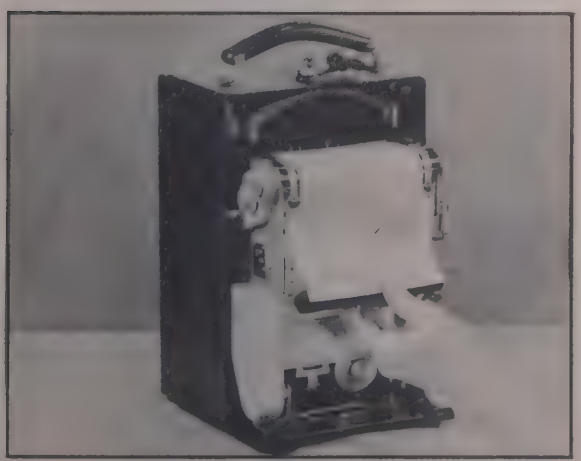


Fig. 5. ATTACHING TO REROLL. Tear or cut chart square across, ready to wrap on reroll stick.

Fig. 6. ATTACHING TO REROLL CONTINUED. Wrap two turns of chart around reroll stick and even chart with ends of stick

THE ESTERLINE-ANGUS MODEL AW GRAPHIC METER

INSTRUCTIONS FOR PLACING IN SERVICE—Continued

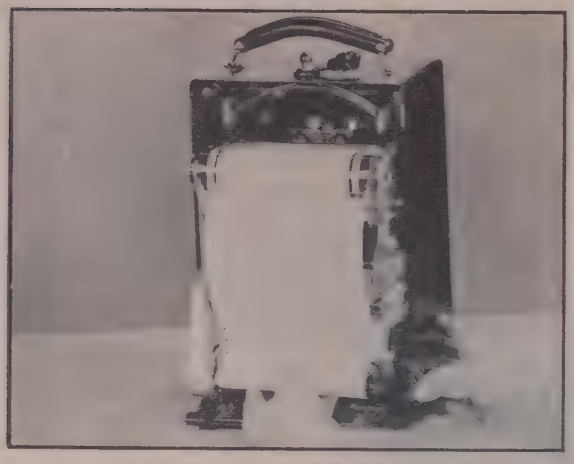


Fig. 7. ATTACHING TO REROLL CONTINUED. Insert reroll latch, keeping flat section under chart. Pull back reroll tab locking slightly.

Fig. 8. REMOVING INK WELL. Raise scale plate. Grasp ink well handles and pull forward, lifting ink well out of meter.

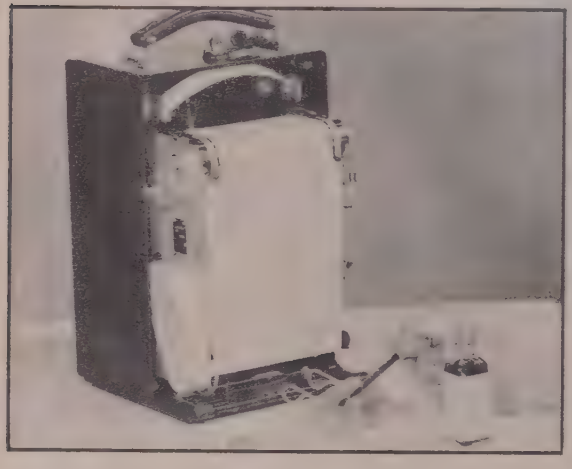


Fig. 9. FILLING INK WELL. Using ink well filler and ink from accessory box, fill ink well to 1/8 inch of top. Replace ink well in meter.

Fig. 10. INSERTING PEN ELEMENT. Place pen element in pen fork, being sure it is properly seated. Pen will remain off of chart until filled with ink.

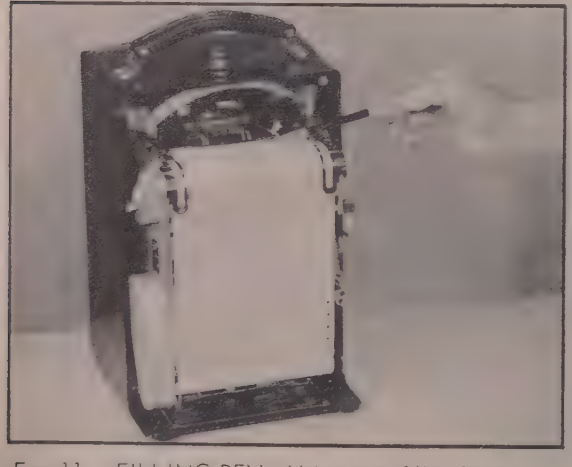


Fig. 11. FILLING PEN. Using pen filler from accessory box, suck pen element full of ink. Watch glass pen to see that all air bubbles are removed.

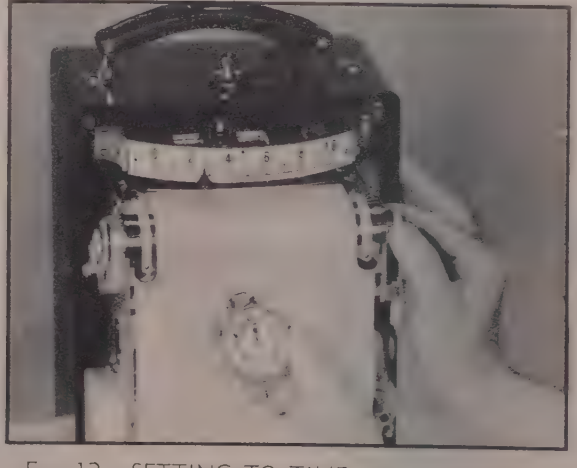


Fig. 12. SETTING TO TIME. Swing pen across chart to see that it inks properly. Turn set wheel until correct time of day appears under pen tip.

ESTERLINE-ANGUS ALTERNATING CURRENT VOLTMETERS

AND UTILITY, (AC-DC), VOLTMETERS

MODEL AW

These voltmeters have the electrodynamometer type of measuring element. Alternating current voltmeters can be furnished calibrated for any full scale voltage from 50 to 750 volts and, by use of an extra multiplier, the top range can be extended to 1000 volts.

Some characteristics of the low voltage voltmeters are different from the regular alternating current voltmeters. The low voltage voltmeter can be calibrated for full scale voltages from 50 to 120 volts. This voltmeter draws .38 amp. for a full scale calibration of 120 volts and will consume 42 watts at 115 volts.

The regular alternating current voltmeter can be calibrated for a full scale voltage as low as 120 and up to 750 volts. This voltmeter draws .13 amps. full scale and will consume 115 watts at 115 volts when calibrated for 150 volts full scale. The low voltage and regular alternating current voltmeters are made for use only on the frequency for which they are calibrated.

The Utility voltmeters are calibrated for any full scale range from 150 to 750 volts and can be used on 1000 volts by using an additional separate multiplier. They are accurate on AC or DC and any commercial frequency. These voltmeters draw .13 amps. full scale and will consume 115 watts at 115 volts when calibrated for 150 volts full scale.

Voltmeters in portable and flush type of cases have the multiplier mounted on the back of the case. The usual standard ranges for portable voltmeters are 150, 300, 600, or 750 volts. The scale is usually marked to correspond to the lowest range. Direct reading charts can be furnished for any of these ranges.

Voltmeters in front switchboard or wall type cases have separate multipliers.

Portable meters which are to be used with potential transformers should have a 150 volt tap.

See the data sheet in this instruction book or the nameplate in the bottom of the case for the ranges of this voltmeter.

ZERO ADJUSTMENT

A zero adjusting lever is located at the bottom of the meter with a pointer extending out over the nameplate. The zero should be set with the voltmeter disconnected. The pen point should be carefully adjusted to read on the zero line on the chart while tapping the pen table with the finger.

DAMPING

Alternating current and utility voltmeters have magnetic damping which is adjusted to the proper strength to bring the pen to rest in the shortest time without making the meter sluggish.

COMPUTING SCALE RANGE

When used without potential transformers, or on direct current, voltmeters are direct reading.

When potential transformers are used the transformer should be connected to the 150 volt tap and the full scale reading is the range of the instrument alone, multiplied by the ratio of the transformer.

For example: To find the full scale reading of an alternating current voltmeter when used with a potential transformer having a ratio of 2300 volts primary to 115 volts secondary:

Range of meter alone, 150 volts.
Ratio of potential transformer 2300 ÷ 115 = 20 to 1.
Full scale range of meter 20 x 150 volts = 3000 volts.

CARE OF THE MEASURING ELEMENT. ELECTRODYNAMOMETER TYPE

If the moving element has a tendency to stick, and not swing freely, the trouble may be eliminated without returning the instrument to the factory. Examine the pen element clearance by pushing it across the scale. If the indicating pen target rubs on the lower edge of the scale plate, carefully bend it to clear.

If the sticking is not caused by the pen target rubbing, take out the chart drive by removing the four corner screws and examine the magnetic damping mechanism at the bottom end of the measuring element. Turn the moving element slowly back and forth by holding to the pen fork and note if the damper disc is rubbing. Rubbing may be caused by dirt or iron filings in the air gaps. Clean the air gaps by drawing a thin piece of sheet iron through them. Care should be taken not to bend the damper disc.

The complete measuring element with terminal blocks and wiring can be removed from the case by taking out the four screws holding the terminal blocks and the three screws holding the measuring element. It is necessary to take switchboard and wall mounted instruments from the panel to get at these screws.

Esterline-Angus measuring elements are designed to be free from trouble and they will rarely ever require any attention. Should the measuring element require any major repairs or recalibration, it is usually best to return the instrument and have this work done at the factory.

ORDERING PARTS

When ordering parts for this recorder, always give the serial number, which will be found stamped on the lower right hand corner of the name plate, inside the meter at the bottom. The meter serial number also appears on the scale plate.

DAMPING

This instrument is equipped with adjustable damping. It has been set at the factory to the proper strength to prevent over shooting on sudden swings. This setting should not be changed unless special conditions warrant it and the change should be made by someone who understands the effect of changing the damping on recording instruments.

If it is desired to change the degree of damping, remove the chart drive from the instrument by taking out the four corner screws. This gives access to the damping mechanism at the lower end of the electrical movement. The two magnets are each pivoted on a vertical axis and held from turning by friction. Each magnet has a pointer projection on the lower edge. The pointer reads on a graduated scale marked 1 to 5. When the pointers are at No. 1 the least damping is obtained. No. 5 setting gives the heaviest damping.

The magnets can be moved by turning them with the thumb and first finger. The degree of damping is designated by the number at which the pointer is set and this number is shown on the data sheet as the damping number.

IMPORTANT

Both damping magnets must be set to the same reading on the graduations to avoid errors in the registration of the instrument.

ORDER CHARTS BY CHART NUMBER AND LETTER DENOTING CHART FEED OR HOURLY MARKINGS

NOTE—Obviously, it is impossible to carry in stock charts in all ranges and speeds listed, but any chart in the list not regularly carried in stock, will be furnished at standard prices and discounts, on orders for twelve or more of one range and chart speed.

Charts for Model AW, LR, MS and EB AC Ammeters and AC and Utility Voltmeters

Approximately quadratic ruling.

Chart Number†	Chart Range	Code Word†	Number Large Divisions	Number Small Divisions	Value One Large Division	Value One Small Division
1000	blank	WYLL	.....	.....	.....	.....
1300	blank	WYJM	10	100	.....	.....
1301	blank	WYKA	15	75	.....	.....
1302	blank	WYKK	8	80	.....	.....
1303	blank	WYKL	12	60	.....	.....
1310	0–5	WYKE	10	100	0.5	.05
1311	0–10	WYKN	10	100	1.	.1
1312	0–15	WYKO	15	75	1.	.2
1312½	0–20	WYRA	10	100	2.	.2
1313	0–25	WYKU	10	100	2.5	.25
1313½	0–30	WYLA	12	60	2.5	.5
1314	0–50	WYLE	10	100	5.	.5
1314¼	0–60	WYLM	12	60	5.	1.0
1314½	0–75	WYLO	15	75	5.	1.0
1315	0–100	WYLP	10	100	10.	1.0
1316	0–150	WYMA	15	75	10.	2.0
1317	0–200	WYME	8	80	25.	2.5
1318	0–250	WYMI	10	100	25.	2.5
1319	0–300	WYMM	12	60	25.	5.0
1319½	0–400	WYMN	8	80	50.	5.0
1320	0–500	WYMU	10	100	50.	5.0
1320½	0–600	WYNN	12	60	50.	10.0
1321	0–750	WYNO	15	75	50.	10.0
1322	0–1000	WYNP	10	100	100.	10.0
1323	0–1500	WYNR	15	75	100.	20.0
1324	0–2000	WYNU	8	80	250.	25.0
1325	0–3000	WYOH	12	60	250.	50.0
1326	0–4000	WYOJ	8	80	500.	50.0
1326½	0–4500	WYNE	15	75	300.	60.0
1327	0–5000	WYOL	10	100	500.	50.0
1327½	0–6000	WYOP	12	60	500.	100.0
1328	0–7500	WYOR	15	75	500.	100.0
1329	0–10000	WYOV	10	100	1000.	100.0
1330	0–15000	WYOW	15	75	1000.	200.0
1330½	0–18000	WYNA	12	60	1500.	300.0
1331	0–20000	WYOZ	8	80	2500.	250.0
1333	0–50000	WYPA	10	100	5000.	500.0

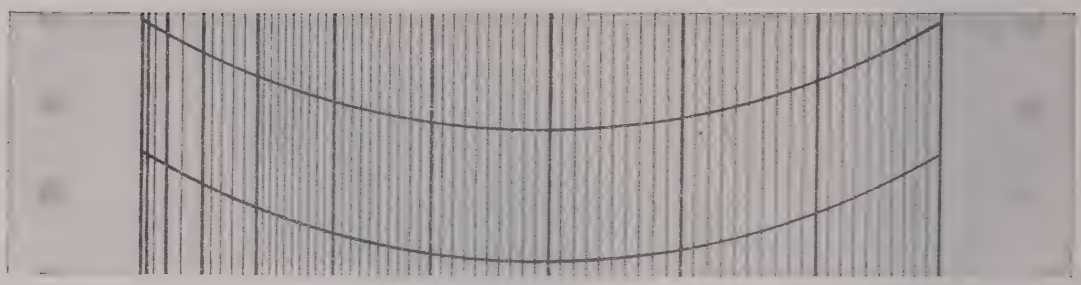
†When ordering, speed designating letter must be added;

NOTE—See back of this sheet for standard rulings.

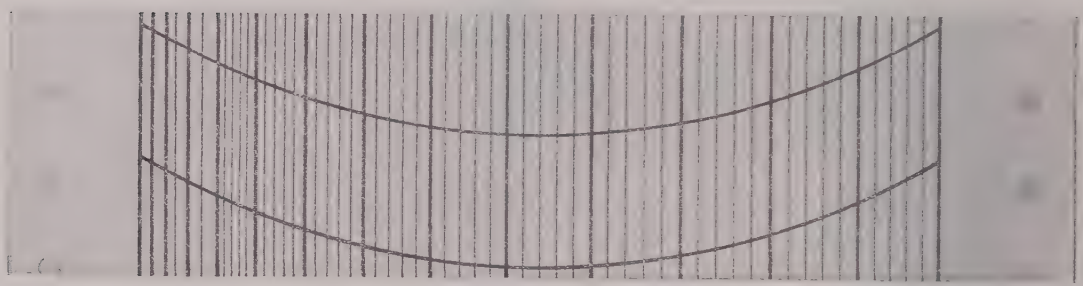
CHART RULINGS

Charts for Model AW, LR, MS and EB AC Ammeters and AC and Utility Voltmeters

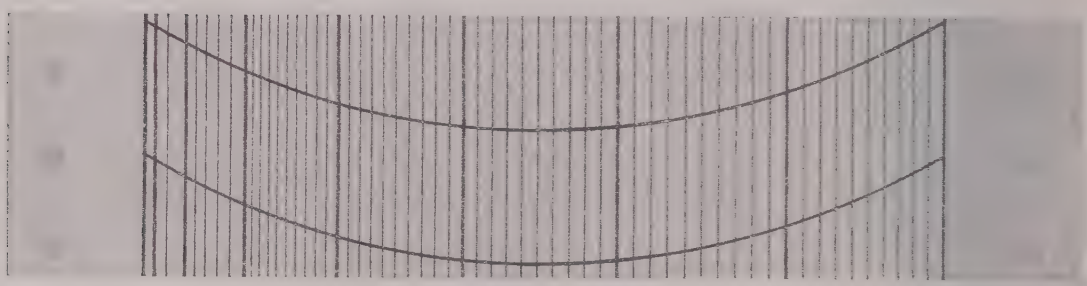
Approximately quadratic ruling. Charts shown actual size.



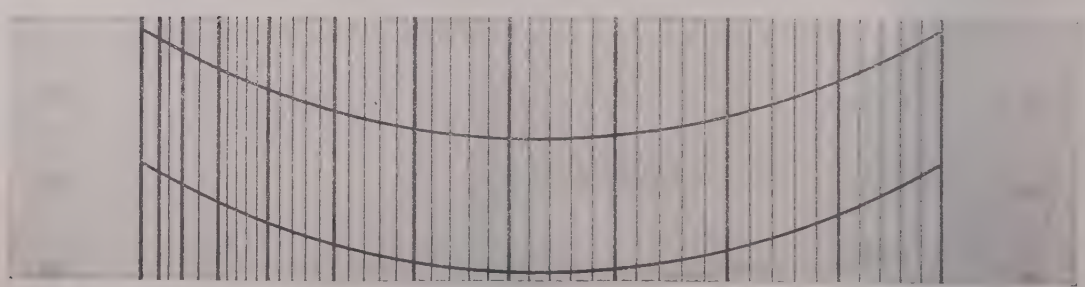
10 Large divisions—100 small divisions—left-hand zero



15 Large divisions—75 small divisions—left-hand zero



8 Large divisions—80 small divisions—left-hand zero



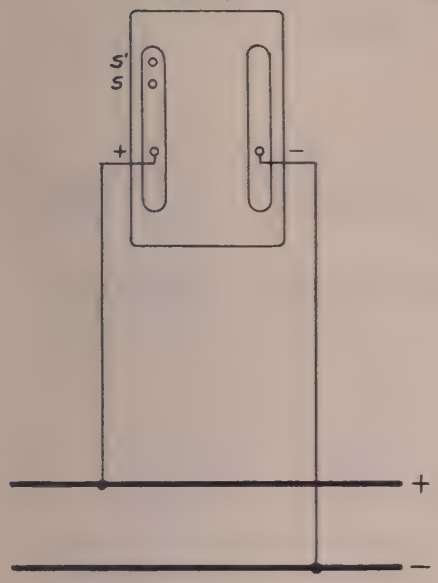
12 Large divisions—60 small divisions—left-hand zero

DIAGRAM OF CONNECTIONS
FOR MODEL AW

ESTERLINE-ANGUS PORTABLE AND FLUSH TYPE GRAPHIC VOLTMETER.

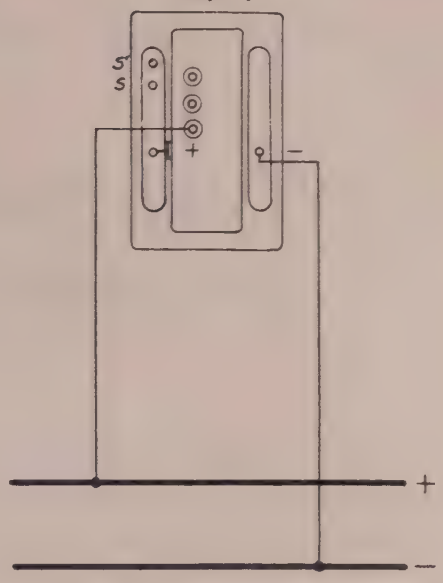
BACK VIEWS.

FIG. 1.



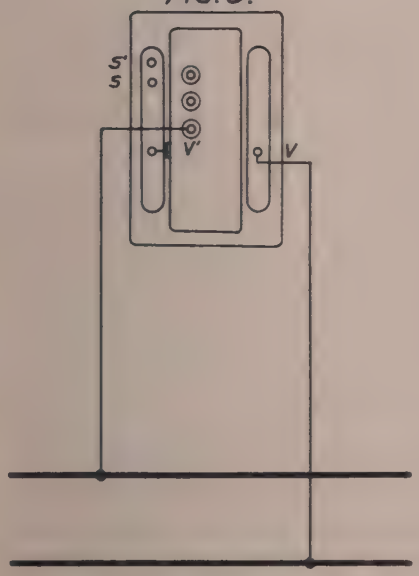
DIRECT CURRENT
WITHOUT MULTIPLIER.

FIG. 2.



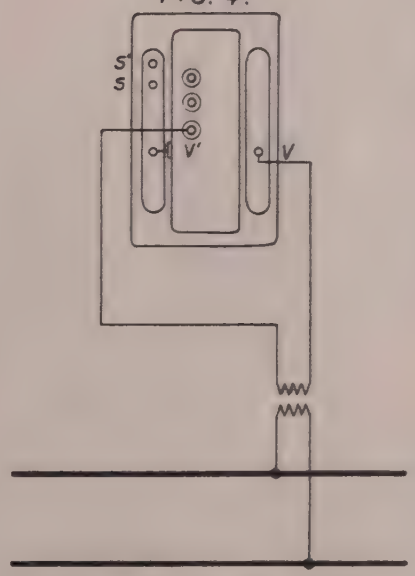
DIRECT CURRENT
WITH MULTIPLIER.

FIG. 3.



DIRECT AND ALTERNATING
CURRENT.

FIG. 4.



ALTERNATING CURRENT
WITH POTENTIAL TRANSFORMER.

VOLTAGE TERMINAL - OR V IS COMMON FOR ALL RANGES, AND MARKING ON OTHER TERMINALS INDICATES THE RANGE FOR THOSE TERMINALS.
METERS WITH SYNCHRONOUS CLOCK- CONNECT CLOCK SUPPLY TO TERMINALS S AND S'.

No. D-940

JULY 30, 1935.

THE GRAPHIC

THE ESTERLINE-ANGUS COMPANY • INDIANAPOLIS • *BULLETIN NUMBER 436*

How to Make Plant Surveys

WITH GRAPHIC INSTRUMENTS

WHEN a manufacturer wants to improve a product, he makes it the subject of research. The big job in manufacturing is to make an efficient application of power and labor to the processes of production. Here is a place ~~where researeh~~ pays. You conduct research to improve the things you make; why not research to improve the making? You will be surprised to find what can be accomplished by actually testing the efficiency of this combination of men and power and machines, which we call a manufacturing plant. At their best, plant surveys are a process of continuous research throughout the plant, to discover where improvement can be made. Well done, such surveys as are described in this bulletin turn up losses and wastes in power and labor which can be overcome; they disclose where maintenance is needed; where production processes can be bettered. Graphic instruments make studies of this kind possible because they record what actually takes place, giving all the characteristics of performance. They work without being watched, so that one individual can be obtaining information at different places at the same time.

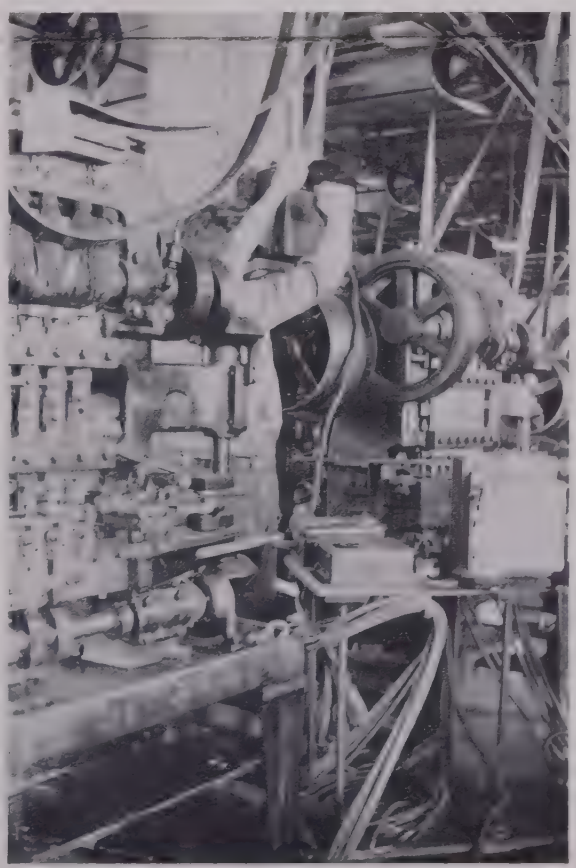


FIG. 1—*This illustration shows the man making a plant survey in the act of connecting his graphic meter in a motor circuit.*

WHY SURVEYS ARE PROFITABLE

The purpose of this bulletin is to show briefly what may be accomplished by a continuous and systematic study of plant operation, and to suggest the procedure which should be followed. It is understood, of course, that no two plants have precisely the same problems, but the principles which apply to the betterment of plant operation are the same, regardless of the character of the plant or its product.

The Kind of Information Obtained

Graphic surveys are made for the purpose of obtaining any information which is valuable in improving the operation of the plant by reducing waste, improving performance, lowering costs or bettering the product. In general, they have to do with four elements which enter into the cost of a product, namely, condition of equipment, power use, employee time and the handling of equipment by workmen. Perhaps an illustration of each of these phases of plant study will make clearer what we mean.

Checking Condition of Equipment

An electric motor draws current from the supply line in almost direct proportion to the work it has to do. By measuring this flow of energy to the motor, we can learn just what it is being called upon to do. A graphic record of the energy taken by the motor gives a picture of just what is going on in the machine which the motor is driving. Any change in the condition of the machine usually causes a change in the character of the record, so that occasional "check-ups" with graphic instruments enable the engineer to "spot" causes of future trouble long before breakdown occurs.

As an example, here are the graphic meter records from a hot lead pump. Figure 3 shows the chart obtained in the course of a survey. This chart was so different from those obtained in previous surveys that the pump was dismantled. Examination showed that some of the internal parts were in bad condition. Figure 2 is a chart made after the machine had been repaired. The test made in time undoubtedly saved the pump from being wrecked.

Stopping Power Waste

If water leaks from a faucet, the loss is evident, but electrical energy can be wasted day after day, and no one will realize the fact, unless someone is looking for the waste. Motors may be started ahead of time or be permitted to run after hours. Lights and equipment may be used

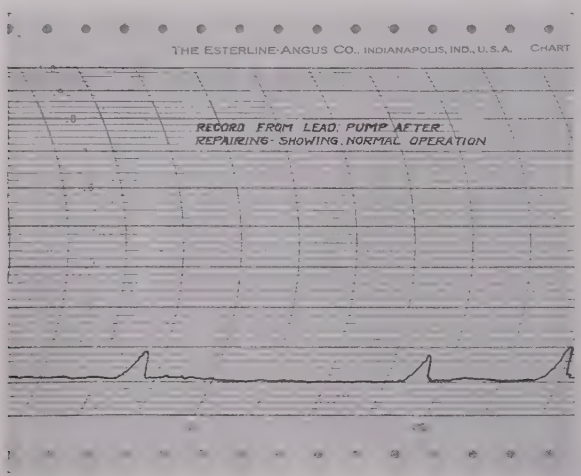


FIG. 2—*This chart shows the normal operation of a pump for handling hot lead in a storage battery plant. The chart in Figure 3 is from the same pump.*

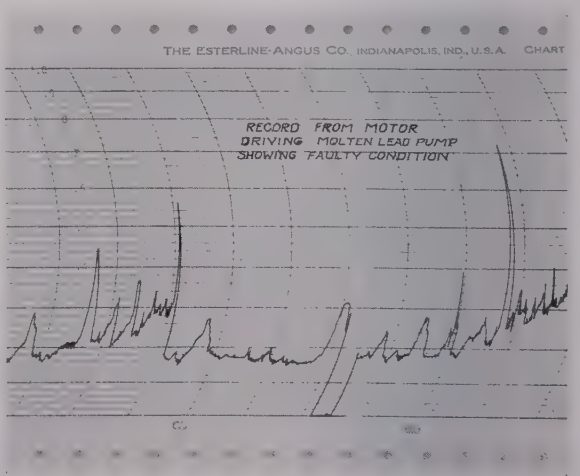

THE ESTERLINE-ANGUS CO. INDIANAPOLIS, IND., U.S.A. CHART
RECORD FROM MOTOR DRIVING MOLTEN LEAD PUMP SHOWING FAULTY CONDITION

FIG. 3—*This is the chart which showed that the lead pump was out of condition. When the pump was taken apart the cause of the trouble was apparent.*

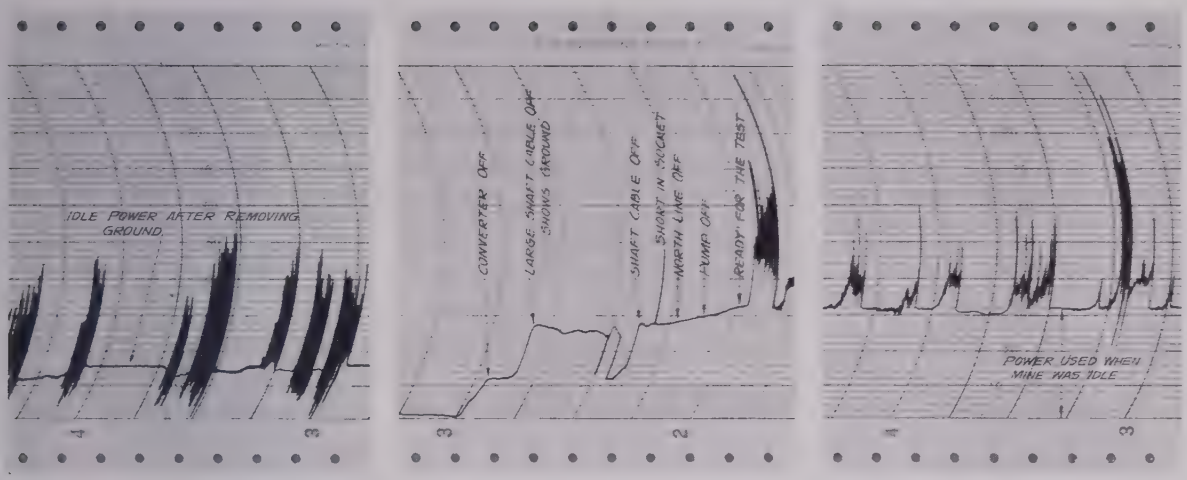


FIG. 4—*The right-hand portion of this chart shows the idle power in a coal mine. The middle portion shows the effect of opening the feeder switches. The left-hand portion shows the idle load after the ground was removed.*

nights and Sundays; grounds may exist; friction losses may mount to abnormal proportions. Occasional surveys with graphic instruments will bring to attention anything unusual in the use of electrical energy.

A graphic wattmeter was left in the main feeder circuit of an Indiana coal mine overnight, and the chart showed a continuous flow of power throughout the night when the mine was idle, as shown in the right-hand portion of the chart. The next morning the circuit switches were opened one at a time, and the loss was found to be on the line to the main shaft. The ground was discovered and removed, and a loss of energy amounting to some $1,800 per year was stopped.

Discovering Labor Losses

We have already mentioned the fact that the electrical energy drawn by a motor increases and decreases with the work the motor is called upon to do. Here then is a simple and convenient way to tell how much productive work is being done by the motor-driven machinery in a plant. A graphic wattmeter connected to the power supply circuit to a department using motor-driven machines often gives a chart which shows an unsuspected loss of productive effort.

For example, here is a chart obtained in a manufacturing plant in Milwaukee between the hours of 12 noon and 4:30 P. M. The load during the noon hour was 84 kilowatts. Work was

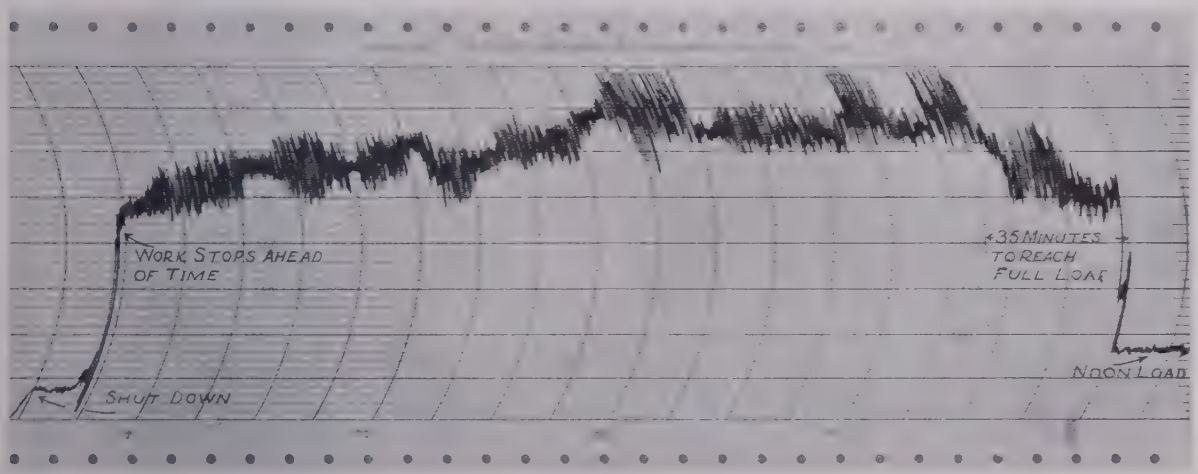


FIG. 5—*This record shows how labor losses may be detected with graphic instruments. This is the afternoon record of a plant supposed to start at 12 o'clock and quit at 4:30. It took 30 minutes to get going at full production, and quitting started at 4 P. M. Loss, $30,000 a year.*

supposed to start at 12. A few minutes before 12 several of the motors were started, and several minutes after 12 the load was only 50 per cent of normal. Gradually work got under way, but it was actually 12:35 P. M. before everybody was at work. Then at 4 o'clock work began to slacken up, so that shutting down was a gradual process until 4:30 P. M., when the motors were stopped. The engineer who sent us this chart estimates that the loss of time represented by this chart amounted to approximately $100 per day, or $30,000 annually. No one knows how long this condition had existed, and it would probably be going on today had not this survey been made.

Handling of Equipment

There is a great deal of manufacturing equipment which is not automatic, but on the other hand, the skill of the operator is a factor in the production scheme. Workmen develop notions of their own; some are inclined to become indifferent or careless; in some instances the man's understanding of the requirements may be faulty. The advantage of using graphic instruments lies in the fact that records can be taken over sufficiently long periods of time, the charts produced by different men can be compared, and the faults can be pointed out to the men. Sometimes it pays to put the instruments in permanently, locating them so the operator can observe the record he is making, but the way to find the faults to be corrected is by a survey of plant operation at regular intervals.

A good example of this phase of survey work was recently sent us by the engineer of a cement plant. A two-speed rotary kiln was operated continuously by three shifts of men. The charts obtained showed that the three crews had widely different ideas of how the same equipment should be handled. The result was lack of uniformity of the product, and reduced output.

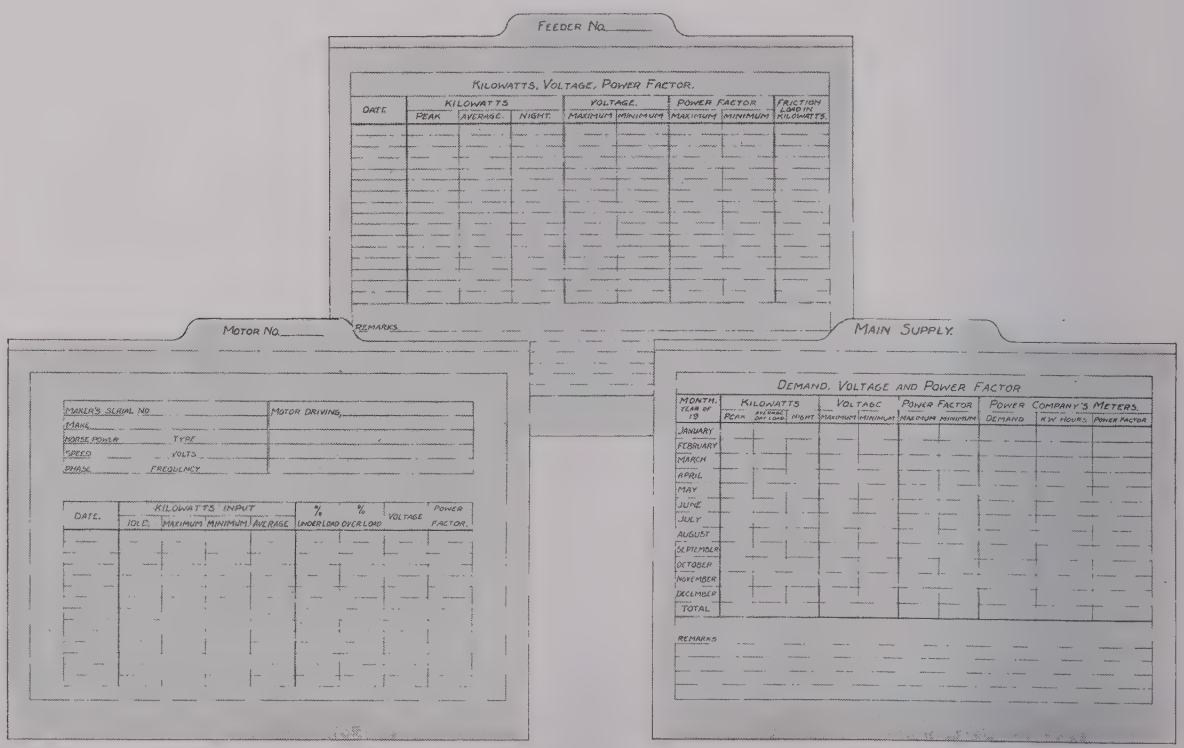


FIG. 6—*Here is a simple way to preserve the charts taken in surveys. Use manilla letter file folders with spaces for data mimeographed on the front. Give each circuit and motor a separate number and file. Label each record chart, date it and place it in the proper file.*

PRESERVING THE SURVEY RECORDS

In order that the work may be done systematically and records kept in a form so that they can be conveniently used, a number of engineers have worked out systems of forms and records which they are using to this end. The first step is usually to prepare a simple drawing, showing the power circuits, with each motor and piece of electrical equipment given a number. A single line is usually used to represent a circuit. Some engineers indicate the size of conductors and the horsepower of motors on this diagram, but this is not essential.

To provide a place for the records taken on each piece of equipment from time to time, and to assemble in one place all the data regarding each unit, it has been found desirable to use standard letter file folders, ruled and lettered, so as to provide spaces for the information obtained. These folders are inexpensive, and can be prepared by the mimeographic or "ditto" process. In cases where whole charts need to be preserved, they can be stamped and replaced in the boxes in which they are originally received.

The record charts from a given machine are dated and numbered to correspond with the number of the machine or circuit on which the record was made, and after the data required are taken from the record and placed in the blank spaces on the folder the chart is placed inside the folder for future reference. It is quite essential that each record chart have on it sufficient notes to make it possible to identify it later. Each test made in a survey usually uses only a few feet of chart, and it is the practice of many engineers to cut or tear off each section, stamp it with a rubber stamp, a sample of which is illustrated on page 8, and then fill in the blank spaces. Some engineers, especially those concerned with maintenance, prefer to have on the face of the folder a space for keeping a record of the dates and character of repairs made. Having provided these simple forms, and with the necessary instruments available, a systematic study of plant performance can be begun.

INSTRUMENTS FOR SURVEY WORK

The instruments used for survey work generally are graphic wattmeters, voltmeters and power factor meters. Unquestionably graphic instruments are vastly superior to indicating instruments for this kind of service. In the first place, they do not require a man to stay with them. With graphic meters all that is required is to connect the instruments in the circuit and leave them to operate as long as is desirable. This means that one man can keep a number of instruments in operation all the time without interfering with his other duties.

Again, much of the information obtained from graphic records comes out of the characteristics of the record itself. The shape of the curve, the values recorded with respect to time, etc., are all important, and this is data which can be secured only with graphic recorders. In order to be able to obtain good records of rapidly varying quantities, we recommend that the wattmeters be equipped with the rapid feed clocks by which the chart can be fed several inches per minute when necessary. Rapid chart speeds are usually not required on voltmeters and power factor recorders.

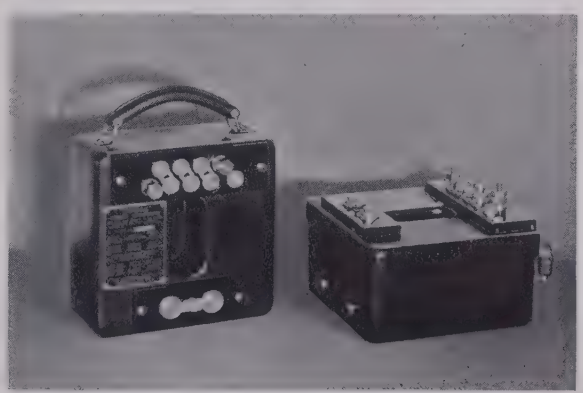


FIG. 7—*On alternating current circuits, current transformers are used to give the instruments the proper ranges. These Esterline-Angus transformers are metal-clad, and they have nine current ranges.*

FIG. 8—*This illustration shows the Esterline-Angus portable graphic meter, designed especially for survey work. It is unquestionably the most dependable graphic instrument in the world.*

Instruments for survey work should preferably be of the portable type, so that they can be moved from place to place conveniently. They should have voltage ranges which will adapt them to the voltages of the different power and lighting circuits of the plant. If both alternating and direct current are in use, the wattmeters and voltmeters should be of the "utility" type, accurate on both AC and DC circuits.

The accessories required likewise depend upon whether both alternating and direct current circuits are to be tested. Standard wattmeters and power factor meters have a current range of 5 amperes, and on alternating current circuits transformers are used to give the instruments the proper current capacities to handle the different circuits to be tested. This company makes a current transformer having nine primary ranges, namely, 10, 12.5, 25, 50, 100, 160, 200, 400 and 800 amperes, the use of which gives a single instrument a wide range of capacities. These current transformers have sufficient volt-ampere capacity to operate both a wattmeter and power factor meter at the same time.

To give the wattmeter the required capacity on direct current circuits, shunts are used. These can be furnished in any desired current rating. In order to reduce the variety of charts required for miscellaneous tests, a chart of one range is usually used in such instruments as ammeters and wattmeters and a proper multiplier used in taking the values from the record chart. Extra copies of charts can be made by blue printing. Many of our customers have devised special trucks or carts on which the instruments and the accessories are permanently mounted and connected. In some plants jacks have been provided on each circuit, so that the instruments can be plugged in quickly.

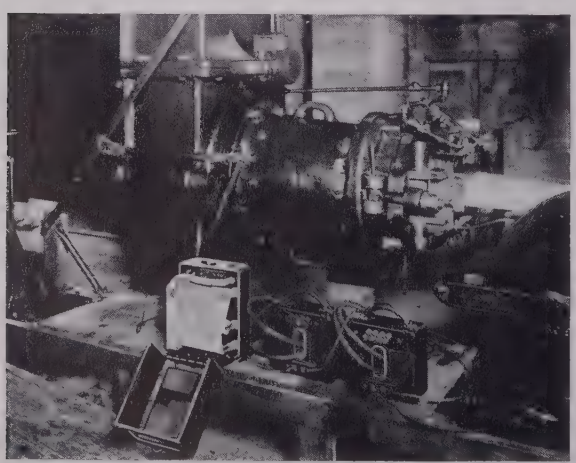


FIG. 9—*Here is a picture of a survey in progress in a plant manufacturing building brick. The transformers and graphic meter are in the circuit of the motor driving the pug mill.*

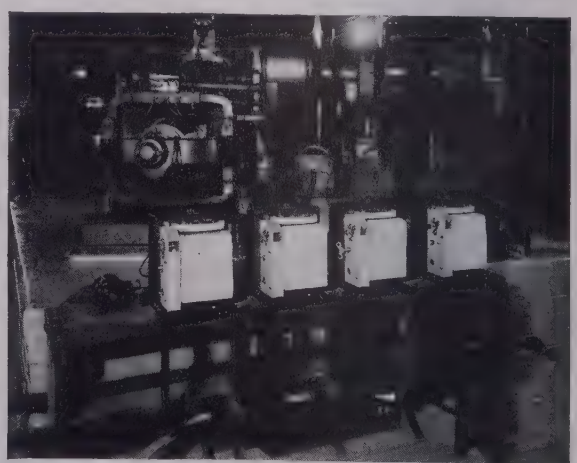


FIG. 10—*Four instruments are in use here, recording kilowatts, voltage, power factor and amperes. This picture was taken in the penthouse of one of Detroit's largest office buildings.*

STUDYING THE TOTAL LOAD

There is certain valuable information to be obtained from the records of total power consumption. It is on account of this that many engineers prefer to place graphic instruments permanently in the main circuit, rather than to make only periodic tests of the total power load. One thing which makes the total load an important consideration is the maximum demand charge. The graphic record of total consumption provides a check on demand measurements, gives prompt information on any tendency toward unnecessary increase in the maximum demand, and shows the result of any steps taken to reduce the peak load.

Frequently the pyramiding of peak loads, due to simultaneous starting of equipment or the operation of intermittently used machinery, may cause an excessive demand charge for an entire month. Any practice or oversight which results in an increased demand will be disclosed by an examination of the charts of the plant power load.

It is important also to be on the lookout for unwarranted use of energy or unnecessary waste of employee time.

We find that watchful engineers are interested in knowing something about the night load, the consumption on Sunday and holidays, how long lights and motors stay on the circuit after the plant stops working, what the load is during the noon hour, how long motors are running before the time for starting work, how long it takes the whole plant to get going at full load in the morning and afternoon, and whether there is a noticeable anticipation of quitting time at noon and in the evening.

Power Factor of the Power Load

It is the practice of most power companies to include a power factor clause in the contracts with large consumers. Industries whose monthly power bills are affected by the power factor as well as the demand, want an occasional check of the overall power factor of the power load. If a power factor meter is not permanently installed, it is the usual practice to make the power factor and demand determinations at the same time.

Voltage of the Power and Lighting Service

Economical and continuous operation of an industrial plant requires that the voltage of the supply be maintained uniformly at the proper value. The ability of heavily loaded motors to start their loads and carry them continuously

FIG. 11—*A paper company in New York uses a small wagon to carry the portable meter and the transformers from place to place. This company also has a large number of graphic meters permanently installed.*

FIG. 12—*Here is a picture of a more elaborate portable testing outfit. There is space in the cabinet below for the instruments and transformers. The set records kilowatts, volts and power factor.*

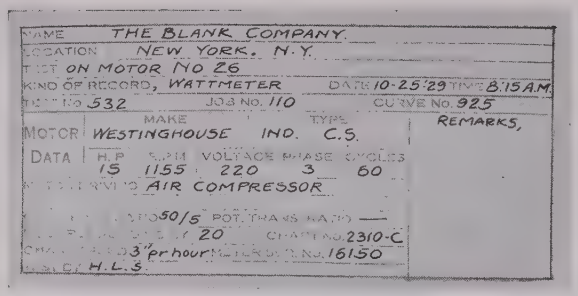

NAME THE BLANK COMPANY
LOCATION NEW YORK, N.Y.
TEST ON MOTOR No 26
KIND OF RECORD, WATTMETER DATE 10-25-29 TIME 8.15 A.M.
TEST No. 532 JOB No. 110 CURVE No. 925
MOTOR MAKE WESTINGHOUSE TYPE IND. C.S. REMARKS,
DATA H.P. R.P.M. VOLTAGE PHASE CYCLES
15 1155 220 3 60
AIR COMPRESSOR
50/5 POT. TRANS. RATIO —
20 CHART No. 2310-C
3" per hour METER No. 16150
H.L.S.

Fig. 13—*Here is a proof of a rubber stamp used by one of our customers for labeling the charts so as to identify them later.*

without overheating depends upon the voltage being kept at the proper value. The starting torque of induction motors drops off approximately as the square of the reduction in voltage. A motor which is carrying all the load it can handle at the proper voltage will quickly overheat if the voltage is appreciably lowered.

Again both the economy and life of incandescent lamps require the maintenance of a constant voltage at the proper value. A supply voltage of only two volts above the rating on the incandescent lamps reduces their life 21 per cent, while a voltage four volts below the rating reduces the illumination by 15 per cent. A regular check of the voltage at the terminals of power and lighting circuits is therefore customary in most industrial plants.

Interpreting Charts of Total Load

Now assuming that the necessary equipment has been provided, the circuits and motors numbered, let us see how engineers proceed to obtain and use the data which graphic instruments make available. Beginning with the main power circuit, the wattmeter, power factor meter and voltmeter are connected so as to record the total load. These should be left in this circuit at least one week, so as to get representative day and night load curves, including Sunday. When the record has been obtained it should be studied to get the answers to such questions as these:

1. What is the maximum plant load in kilowatts?
2. On what day of the week did it occur?
3. Was the peak load the same for each day?
4. If not the same, why not?
5. What was the load during noon hours?
6. Was it the same each day; if not, why not?
7. What is the night load?
8. Was the night load the same each night?
9. Is there evidence of waste of power by starting equipment before hours in the morning or letting it run after the plant is supposed to shut down?
10. How does the peak load compare with the power company's demand charge for the previous month?
11. How long did it take the plant to reach full power load after starting time in the morning and afternoon?
12. Is there evidence of a tendency to anticipate quitting time at noon and in the evening?
13. What is the maximum and minimum power factor of the load?
14. When did minimum power factor occur, and how do you account for it?
15. How does the power factor compare with that on which your power bill is based?
16. What is the maximum and minimum lighting voltage at the main bus?
17. When do maximum and minimum lighting voltage occur?
18. What is the maximum and minimum power voltages at the main bus?
19. When do maximum and minimum power voltages occur?
20. What is the voltage drop between the bus and the lamps at different points in the plant?
21. What is the voltage drop between the main power bus and the different motors in the plant?
22. How does the voltage at the lamps compare with the voltage rating of the lamps used?

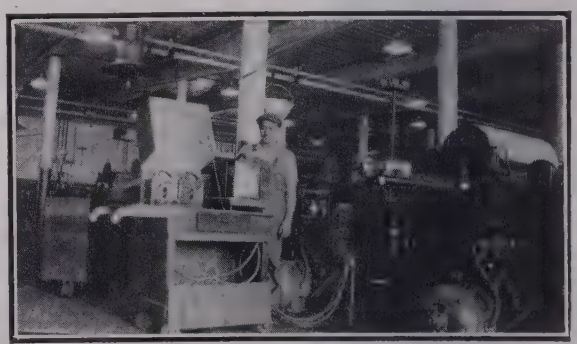


Fig. 14—*This is a picture of a survey in progress in a Georgia textile mill. This test bench is made of wood.*

CHECKING UP THE DEPARTMENTS

The next step is to secure records on the different divisions or departments of the plant, which enables the engineer to localize some of the causes of undesirable conditions that may be shown by the load curve of the plant as a whole.

For example, if the record of total power shows that productive effort lags in the morning and afternoon, or that quitting time is anticipated by workmen, the next step is to find in what departments this occurs. One of the advantages of graphic instruments is that this information can be obtained by placing the meters in circuit at some remote point, and the exact conditions recorded because no one else is aware that such a test is being made. Where group drives are used, it is a good practice to occasionally check up the friction load of each division of the plant. This of course must be done when the machines are idle, but usually some surprising results are obtained.

In most instances a single day's run is sufficient for a departmental test, although things may be disclosed which will make advisable several days' run in order to see if such conditions repeat themselves. In most plants engineers use only graphic wattmeters on departmental feeders, and in many industries the information gained from such records has been of such value as to result in the installation of graphic instruments permanently in the power feeders to each department. Following is the information which usually can be obtained from the graphic records of the department:

1. Did the department start on time in the morning and at noon?
2. How long did it take for the department to reach full power load in the morning? How long after lunch?
3. To what extent was quitting time anticipated at noon and in the evening?
4. What is the friction load in the department?
5. Has the department a peak which corresponds with the total peak, and if so, what causes it?
6. Are motors started at the proper time in the morning and afternoon, and are they shut down promptly at noon and at quitting time?
7. What is the night load? The noon load?
8. Is there anything in the record which gives a clue to waste of power or of employee time?
9. What portion of the demand charge and energy consumption should be allocated to this department?
10. What is the power factor?
11. If the power factor is low are there any large induction motors that could be replaced by synchronous motors?

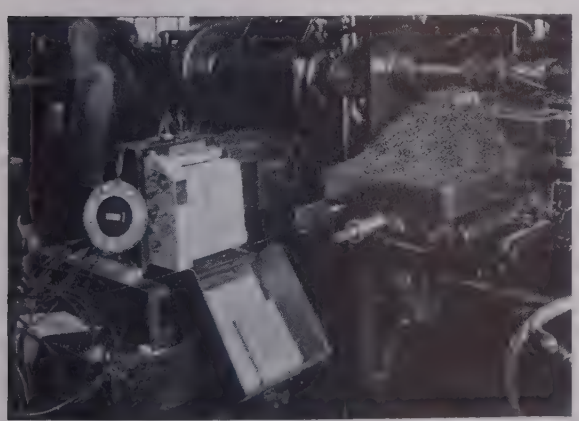


FIG. 15—*A survey in progress in a machine shop. The instrument does not in any way interfere with the progress of the work.*

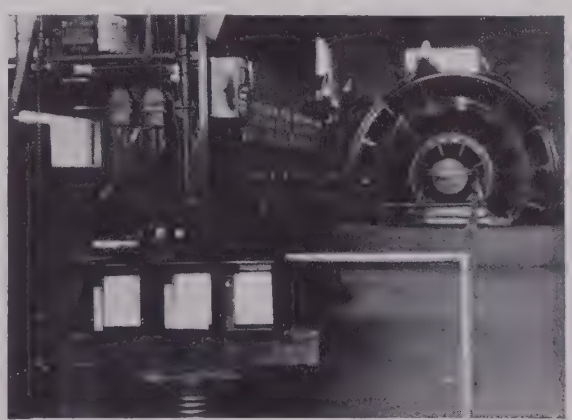


FIG. 16—*This shows a survey in progress in a coal mine. The kilowatts, amperes and power factor of the hoisting equipment is being recorded.*

CHARTING INDIVIDUAL MOTORS

When the records of total load and of the departments have been obtained, the next step is to test each individual unit in the plant. The records of total load and those of the departments give a general, overall measure of conditions, while the tests of individual units show what each piece of equipment is contributing to the total result. Correction of any faulty condition shown by the overall record can best be done by carrying out the test on the different units, as it is these which show where the remedy must be applied.

On small units, say 50 horsepower and under, most engineers use only a graphic voltmeter and wattmeter, but on units larger than this it is customary to employ a power factor meter in addition. In making records on individual machines the engineer should see to it that conditions are normal, and he should be on the lookout for information which may affect any one or all of the different elements of cost, and in many cases the quality of the product as well. Many engineers in making such tests for information on power conditions have discovered things bearing on labor losses, processing, condition of equipment, etc., which were of equal if not greater importance than the data they were actually seeking.

Such tests as we have described are especially illuminating in showing the performance of automatically operated equipment, such as pumps, air compressors and fans which are motor driven and automatically started and stopped. The record shows when and how long each piece of equipment is operated, and how long it was idle each day. It discloses waste if the automatic equipment is not functioning properly.

The length of time instruments should remain in the circuit of an individual machine depends altogether upon conditions. In some cases a 24-hour run is necessary; in others, a full working day, and in still others a much shorter time will suffice. With many types of load it is better to use a slower chart speed and a longer time in order to cover all conditions, and in other cases a shorter time with rapid chart speeds is a better procedure. In many instances, for example, where the motor is driving a group of machines or a line of shafting, it is well to have a portion of the record show the idle or friction load in order to discover any unusual conditions which may have developed since the last survey.

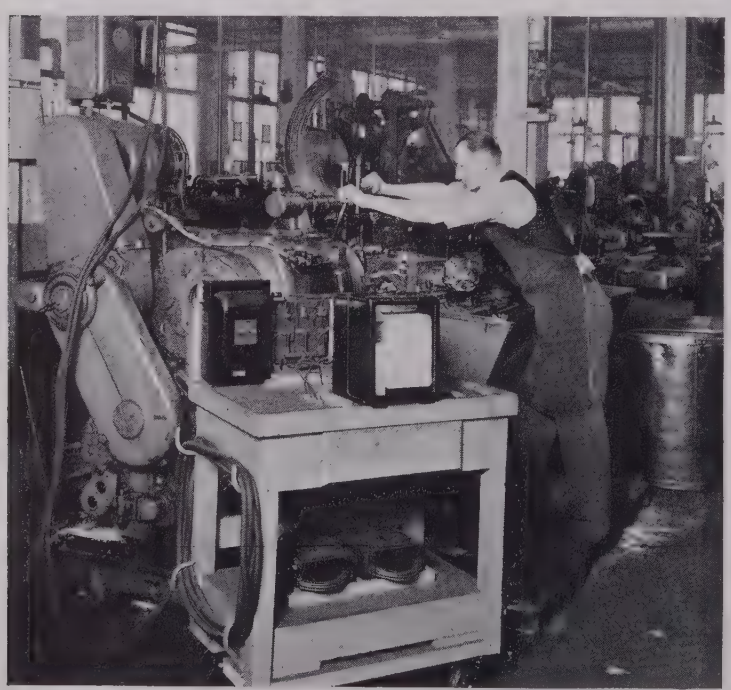


FIG. 17—*Here is another home-made test bench, used by a Cleveland manufacturer of automobile parts. This company also makes most of its time studies with graphic meters.*

The records taken in the survey of individual machines should be studied for the answers to such questions as the following:

1. If the unit is a motor, what is its rating?
2. What is the maximum, minimum and average load on the motor?
3. What is the power factor taken at the motor?
4. If the motor is overloaded, what is the horsepower of the motor that should replace it?
5. If the motor is underloaded, what size should be put in its place?

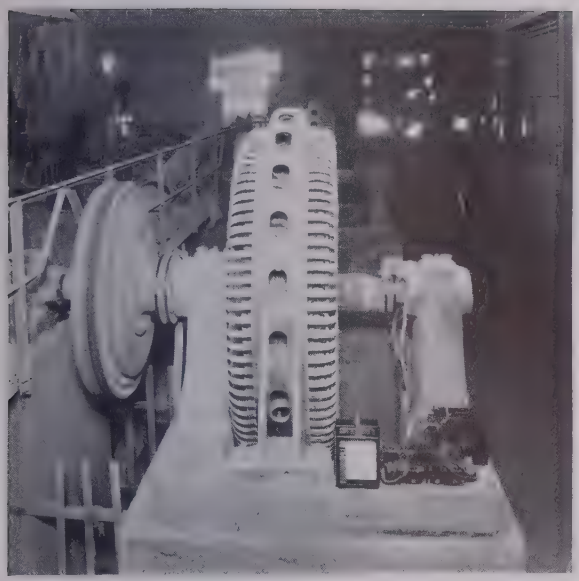


FIG. 18—*A power survey in a modern cement mill. The instrument is recording the operation of the pulverizing machinery.*

6. Is the voltage at the motor terminals the proper value?
7. How many KW does the unit contribute to the peak load?
8. Is this a unit which could be operated on "off peak" service to reduce the maximum demand?
9. Is the load on this unit one of those contributing to any loss of productive effort shown by the departmental record?
10. What is the idle or friction load of the unit?
11. Does the friction load show any marked increase since the last survey?
12. Does the record show any characteristics which indicate a faulty condition of the motor or the equipment which it drives?
13. Does the record show any unnecessary loss of time on the part of the operator of the equipment?
14. How does the character of this record compare with others taken on similar equipment in the plant?
15. Does the record disclose any important information regarding operations or processes, which is of value in reducing cost or maintaining the quality of the product?

USING THE INFORMATION

The reader will recognize at once that the information obtained by such a survey as we have described touches the interests of several departments of a modern industrial plant. Purchase or generation of power, maintenance, cost determination, engineering, production and inspection are all at times covered in the records obtained.

We know that in some plants the surveys are made by one department, usually either maintenance or engineering, and then the records with proper interpretation are made available to other departments through the medium of an efficiency committee representing all departments. A systematic study of plant operation usually discloses some faults, short-comings and oversights of men, and it is quite important to have a set-up which will obtain results without creating friction.

Reports to Executives

Without question the most far-reaching results are being obtained in those plants where a complete report of each survey, with proper summary and conclusions, is placed in the hands of the management. From the executive, the head of each department touched by the report receives the decisions or instructions of the man-

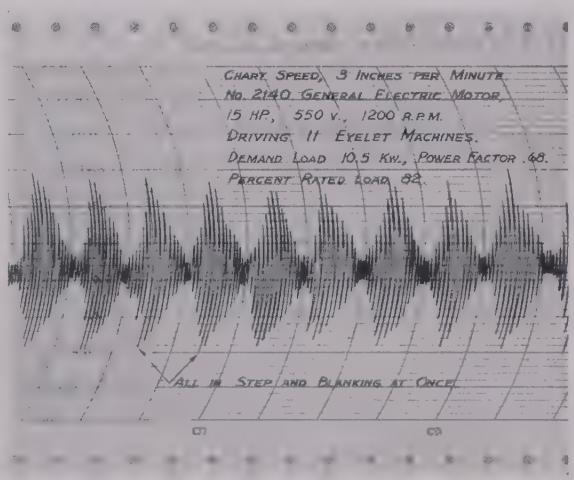
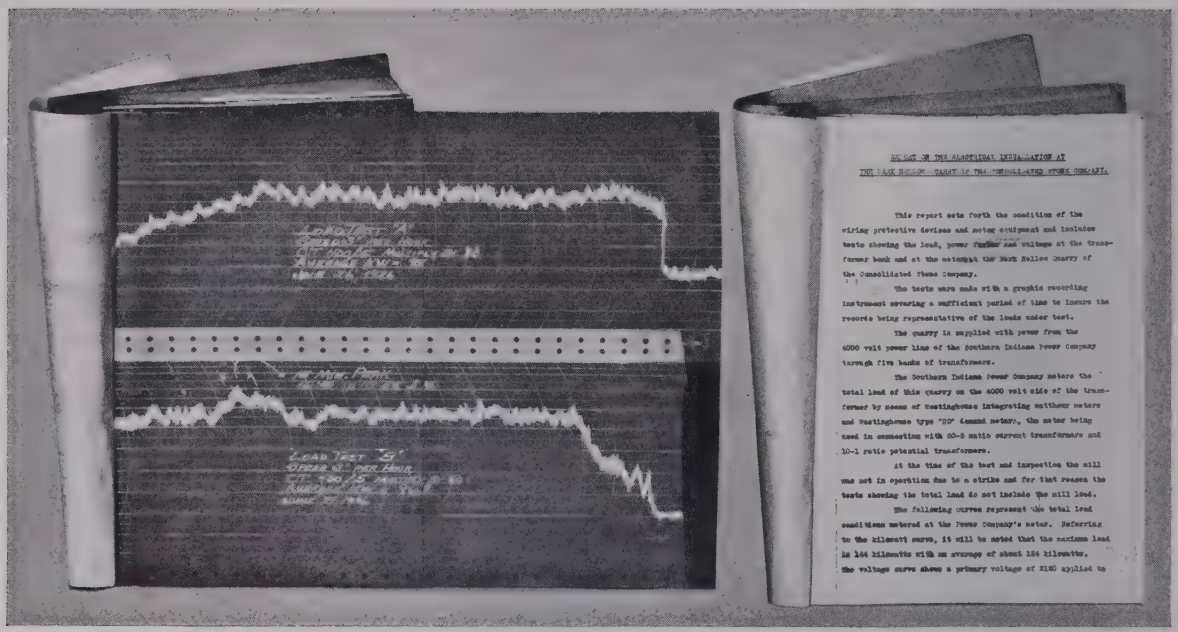


CHART SPEED, 3 INCHES PER MINUTE.
NO. 2140 GENERAL ELECTRIC MOTOR.
15 HP., 550 V., 1200 R.P.M.
DRIVING 11 EYELET MACHINES.
DEMAND LOAD 10.5 KW., POWER FACTOR .48.
PERCENT RATED LOAD 82.
ALL IN STEP AND BLANKING AT ONCE!

FIG. 19—*Here is a chart made in a survey of a New England manufacturing plant, which disclosed that a number of group driven machines were putting an unexpected strain on the belt and bearings.*



This report sets forth the condition of the wiring protective devices and motor equipment and includes tests showing the load, power factor and voltage at the transformer bank and at the entrance to the Stark Keller Quarry of the Consolidated Stone Company.

The tests were made with a graphic recording instrument covering a sufficient period of time to insure the records being representative of the loads under test.

The quarry is supplied with power from the 4000 volt power line of the Southern Indiana Power Company through five banks of transformers.

The Southern Indiana Power Company meters the total load of this quarry on the 4000 volt side of the transformer by means of Westinghouse integrating watthour meters and Westinghouse type "20" demand meters, the meter being used in connection with 60-5 watts current transformers and 10-1 ratio potential transformers.

At the time of the test and inspection the mill was not in operation due to a strike and for that reason the tests showing the total load do not include the mill load.

The following curves represent the total load conditions metered at the Power Company's meter. Referring to the kilowatt curve, it will be noted that the maximum load is 144 kilowatts with an average of about 136 kilowatts, the voltage curve shows a primary voltage of 2180 applied to

FIG. 20—*Where the results of a survey are to be reviewed by others, it is often desirable to draw up a report, which will enable those who are not familiar with the details to understand the findings and the recommendations. We have prepared a sample report which will be sent upon request to those interested.*

agement and uses the report as a basis of carrying out the instructions or putting into execution the decisions based upon the report. In some plants an efficiency committee, composed of key men drawn from different departments, is appointed. The department making the survey reports its findings to this committee. This group considers each cause of inefficiency and waste and makes recommendations for the solution of each problem.

The results which are being obtained in this manner are in many instances really remarkable. In one instance more than twenty-four thousand dollars annually was cut off the power bill; in another seventy-four thousand dollars a year was saved on the pay roll. From the experiences of a number of engineers, we have drawn up a sample report, which shows the wide diversity of information that may be expected from a carefully conducted survey. A copy of this report will be sent free upon request to those who are interested in following the subject further. Simply fill out and mail the enclosed card.

Everything points to the need of increasing attention to the subject of making power and labor more productive, of decreasing waste, of making the entire plant cost-conscious. This company has specialized on this subject for nearly thirty years, and you have the privilege of discussing the subject with our field representative, without incurring the slightest obligation.

THE ESTERLINE-ANGUS COMPANY

Specializing Exclusively in the Manufacture of Graphic Instruments

INDIANAPOLIS, INDIANA, U. S. A.

Bulletin Number 436

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Sales Offices in All Principal Cities

LIST OF
SUPPLIES, ACCESSORIES AND PARTS
FOR MODEL AW GRAPHIC INSTRUMENTS

CHART - Specify by chart number if known. Where an existing chart is to be duplicated, the number will be found on the chart at 3-foot intervals. If chart number is unknown, specify range, chart speed and serial number of instrument. All charts are 103 feet long. At 3" per hour (the speed most frequently used) one chart will last for 15 days. Price (printed record charts):

Lots of 1-23	$1.30 net each.
" " 24-47	1.15 " "
" " 48-95	1.00 " "
" " 96-249	.85 " "
" " 250-499	.81 " "
" " 500-999	.77 " "
" " 1000-1999	.72 " "
" " 2000 or over	.68 " "

INK - Specify whether to be furnished in 2-oz. or 16-oz. bottles and whether red or green is desired. A 16-oz. bottle should be on hand for each 12 to 24 charts. Price:

2-oz. bottles, lots of 1-9	.50 net each
2-oz. bottles, lots of 10 or more	.40 " "
Pint bottles, lots of 1-9	2.00 " "
Pint bottles, lots of 10 or more	1.75 " "

GLASS PEN POINT, #82C - A spare glass pen point should be kept on hand for each meter. Price:

Lots of 1-9	.50 net each
" " 10 or more	.40 " "

INKWELL FILLER - "Ink dropper". Used to transfer ink from bottle to inkwell. Price: 25¢ net.

PEN FILLER - Has duck bill tip. Used for priming pen. Also for cleaning glass pen and pen element. Price: 50¢ net.

INKWELL, #8516 - Main inkwell for all Model AW instruments except operation (time) recorder. Not for chronograph pen if one exists. Price: $2.50 net.

CLOCK WINDING CRANK, #8290 - Also for winding reroll spring on Model AW synchronous motor and "phantom" chart drives. Price: 75¢ net.

CLOCK OIL, 1/3 oz. bottle - For all chart drives. Price: $1:00 net.

ACCESSORY KIT "A" - Includes 2-oz. bottle red ink, glass pen point, inkwell filler and pen filler, all in round cardboard container. Price: $1.75 net.

PEN ELEMENT, COMPLETE WITH GLASS PEN POINT,

#8510 - For measuring element on all Model AW instruments except operation (time) recorder. Price: $3.00 net.

#9892 - For chronograph pen (where one exists) on instrument with serial number 31000 or above. Price, with inkwell $4.50 net.

____ - For chronograph pen (where one exists) on instrument with serial number below #31000. Serial number of instrument must be specified when ordering. Price, with inkwell: $4.50 net.

#9056 - For operation (time) recorder serial #25000 to #30782. Price: $2.50 net.

#9856 - For operation (time) recorder serial #30783 and above, Price: $2.50 net.

LEADS - For portable instruments and for current circuits of DC wattmeters and DC ammeters. Specify serial number of instrument and lead length. Standard length is 5 feet. Price (standard 5-foot leads:)

Current Leads - $2.00 net each.
Potential Leads - $1.00 " "

BRUSHES FOR EXTERNAL DC MOTOR,

A20 - For 125 volt or 250 volt motor. Price: 30¢ net per pair.
M15 - For 12-48 volt Motor. Price: 30¢ net per pair.

BRUSH AND SPRING ASSEMBLY FOR TACHOMETER GENERATOR,

2 - #6332 Brushes and 1 - #6336 spring - for Model C tachometer generator. Price: $4.00 net lot.

2 - #5332 brushes and 1 - #5374 spring - for Model A or Model B tachometer generator. Price: $4.00 net lot.

LAMP FOR FLUSH METER,

115 volt - Price: 50¢ net.
230 volt - Price: 75¢ net.

INSTRUCTION BOOK - Covers care and use of instrument and provides wiring diagram. Serial number of instrument must be specified when ordering. Price: "No charge".

All above prices are f.o.b. Indianapolis, Indiana. Terms: Net 30 days.

SHIPMENT: 1 to 5 days.

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c/o Nearest representative (see last page of catalog for name and address)

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